Weather Impact on Air Quality in the Hampton Roads Area

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History

Before 1200 CE, air pollution resulted from the burning of wood, tanning hides, decaying trash, and the smelting of ores. In as early as 3 BCE, Theophrastus, a student of Aristotle, complained of a disagreeable smell. The Romans complained of oppressive air and made their first chimneys 7-8 m tall to avoid further contaminating the air. There is much evidence of lead, copper, and zinc smelting which produced many sulfides.

In the 1200-1700s, limestone kilns heated with oak to produce quicklime produced organic gases, nitrogen oxides, carbon dioxide and particulate matter. London had a shortage of wood and used sea-coal, which had a high sulfur content. Again, pollutants sulfur dioxide, carbon dioxide, carbon monoxide, nitrogen oxide and particulate matter formed. In 1285, a commission was established to remedy the severe pollution, which was causing the destruction of buildings, palaces, paintings, clothing, water bodies and plants.

In 1700-1840, with the invention of the steam engine and the Industrial Revolution, there was a massive increase in coal combustion. It was used in manufacturing, home heating, and transportation. Many laws were created during the 1800s, but few, if any, were enforced.

By the 1900s, ordinances existed in 175 municipalities in the United States and by the 1940s the number had increased to over 200. Smog first appeared in Los Angeles in the 1940's. The first state air pollution law in the United States was adopted in 1947.

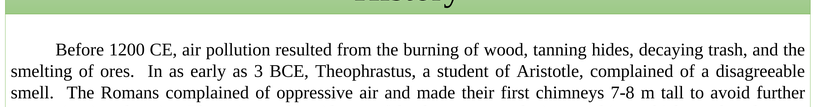
The first Clean Air Act was created in 1963 and called for research on the sources and effects of air pollution. It was amended in 1965 to create standards for hydrocarbons and carbon dioxide. The Clean Air Act in 1970 identified seven criteria pollutants (CO, Pb, NO_2, O_3 PM_{10}, $PM_{2.5}$, and SO_2), and established air quality standards.

Frontal Systems

Cold Fronts

A cold front forms when cold, dense air moves into a region that is occupied with warm, less dense air. As a cold front moves, it becomes steeper, sometimes twice as steep as a warm front. It moves more rapidly than a warm front, which causes it to overtake the warm front and push the warmer, moist, less dense air upwards at a rapid speed. This can cause towering cumulonimbus clouds to form. Once the front has passed, the temperature decreases, the wind shifts, and drier air moves into the area. Behind the front, cumulus or stratocumulus clouds may form.

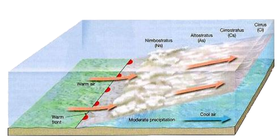
Cold Front Cloud Progression



Cirrus — Cirrocumulus — Altocumulus — Cumulus — Towering cumulus — Cumulonimbus

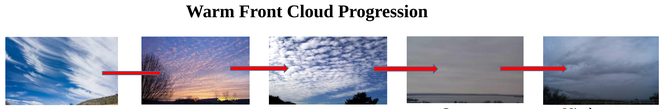
Warm Fronts

A warm front forms when warm, moist air moves into a region with cooler, drier, more dense air. The warmer, less dense air tends to move up and over the cooler drier air, causing numerous clouds to form and bringing precipitation. Warm fronts are usually preceded by a sequence of clouds. The first sign of approaching warm fronts is usually the appearance of high, thin cirrus clouds. As the front gets closer, they change into cirrostratus clouds and then into altostratus clouds. These give way to thicker stratus and nimbostratus clouds and precipitation will begin. Warm fronts have a slower rate of movement and can produce precipitation over a large area. Temperatures and moisture levels increase and the winds shift.



Warm front produced as warm air glides up over a cold air mass.

Warm Front Cloud Progression



Cirrus — Cirrostratus — Altostratus — Stratus — Nimbostratus

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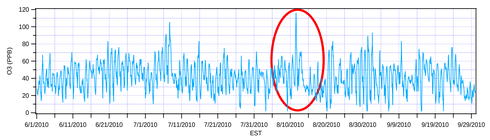
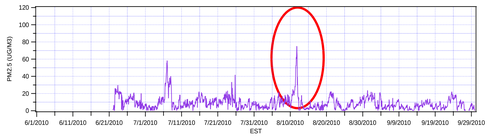
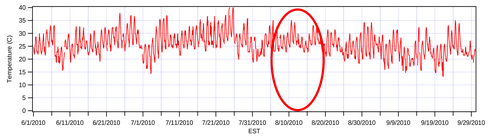
Ozone



PM 2.5



Temperature



Pressure

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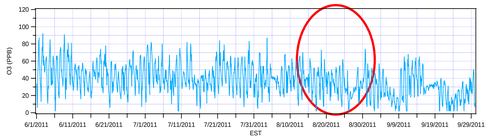
Ozone



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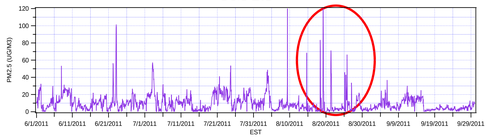
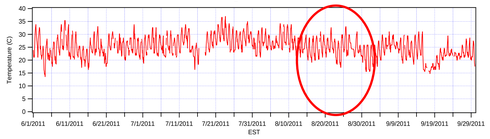


Temperature



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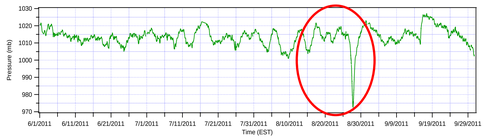

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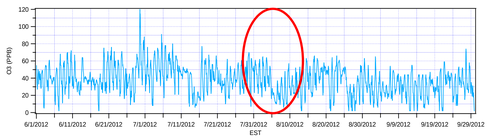
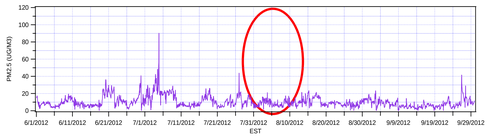
Ozone



PM 2.5



Temperature

Pressure

Analysis

Ozone (O_3) is a colorless gas made up of three oxygen atoms bonded together. It is normally found in the Earth's stratosphere, 20-30 miles up in the atmosphere, protecting Earth from the sun's dangerous rays. However, when it is found near the Earth's surface, it is considered to be a criteria air pollutant. Tropospheric ozone is created by reactions of volatile organic compounds (VOCs), nitrogen oxide (NO), and nitrogen dioxide (NO_2) in the presence of sunlight. On warm sunny days the heat and sunlight will drive the ozone levels up and the winds will disperse the pollutants. Ozone levels start at lower levels at the beginning of the day and increase as the day progresses.

Particulate matter (PM) is a mixture of solid particles and liquid droplets that can be found in the air. They are inhalable fine particles with diameters less than 2.5 micrometers or coarse particles less than 10 micrometers. Primary particles are emitted directly from their source-construction sites, unpaved roads, fields, smokestacks, or fires. Secondary particles form in reactions with sulfur dioxide and nitrogen oxides emitted from power plants, industries, and automobiles.

As can be seen from the data above, before the front passes, the temperatures, pressures, O_3, and $PM_{2.5}$ are at higher levels. As the front passes, the pressure begins to drop, indicating the movement of the front through the area. The O_3 and $PM_{2.5}$ remain steady and begin to fall because the dropping temperatures, rainfall, and winds begin to disperse the O_3 and $PM_{2.5}$. After the front passes, the O_3 levels and the $PM_{2.5}$ levels decrease. As the pressures begin to rise and the temperatures return to normal summertime levels, the O_3 and $PM_{2.5}$ also begin to increase until the next passage of a front clears the air again.

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References

- Environmental Protection Agency
- Fort Air Partnership
- STORM Project Dr. Alan Czernetski
- GA Tech
- CAPABABLE website
- National Climatic Data Center
- Wunderground